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INFRARED BACKGROUND MEASUREMENTS

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains the findings of balloon flights in 1977 which studied enhanced infrared emissions which have been observed at high altitudes in the Fairbanks, Alaska area. Very weak fluctuations were observed for very short periods of time.

TABLE OF CONTENTS

I. INTRODUCTION

This program is a continuation of a study of enhanced infrared emissions which have been observed at high altitudes in the Fairbanks, Alaska area. Data from 1975-1976 are presented elsewhere[1] while this contract covers flights in 1977. These enhancements have been shown to originate at altitudes in excess of 40 km. Information concerning the altitude at which the phenomena originate is of importance in understanding the observations. One method for obtaining altitude information is by triangulation if the phenomena can be observed from points widely separated in space. The accuracy of such a technique depends on its spatial extent. Measurements indicate that the gross structure of the phenomena probably extends over more than twenty degrees in azimuth; however, it has not been established that an exact temporal correlation exists over such a large angle. Therefore, it might be possible to identify a sufficiently narrow region for triangulation experiments by searching for temporal correlations in measurements from platforms separated in space.

The objective of the 1977 Alaskan flight program was to determine the angular extent of close temporal correlations in the fluctuations. Previous data taken with the four-field filter radiometer with a square detector array exhibited good correlations between detectors with 4° of angular separation. Calculations showed that useful altitude information can be derived if angular spreads of at least twice this size are used. The 1977 measurement was to determine the degree of temporal correlation exhibited at various angular spreads up to 60°.

II. BALLOON FLIGHT PROGRAM (1977)

A. Preparations

The nitrogen-cooled filter radiometer, with a four-field linear detector array, was the only instrument available for the measurements, but its optical system limited the field-of-view of the detectors to a 9° extreme spread. It was necessary, therefore, to design and construct additional single-channel radiometers to obtain simultaneous measurements for separations greater than 9°.

The single-channel radiometers were to be small and light enough to permit one of them to be rotated in azimuth upon command, thereby permitting correlation measurements at a variety of angular separations with an identical fixed instrument. Two were constructed: each weighed approximately 35 pounds and was approximately 30" in length by 9" in diameter. The cryostat hold-time was in excess of 25 hours and the N.E.R. was 10^{-10} w $cm^{-2} sr^{-1} \mu^{-1}$ when filtered for a 12 c.p.s. cut-off frequency. The systems were to operate in the D.C. mode with an internal calibration blackbody designed to be thrown into the field at 70-second intervals. A broad band output was provided to permit frequency measured up to ~2 kHz.

The performance of the four-field radiometer with a linear detector array during the 1976 Alaskan series was quite disappointing. Consequently, extensive modifications were performed on the unit in preparation for the 1977 Alaskan flights. The chopper and chopper drive assembly were modified and tested to assure stable frequency and amplitude operation from room temperature down to 77°K. The wiring internal to the detector dewar was changed and re-routed. These modifications materially reduced the microphonic noise from the detectors.

The preamplifiers also were changed. Those used with the detectors for the 1976 series were originally installed for the square array utilized on previous flights. They performed well with the Cu:Ge

detectors of the square array but exhibited a tendency towards parasitic oscillations and electronic cross-talk with the higher impedances of the Ge:Hg detectors in the linear array. New preamplifiers were constructed utilizing newly developed electrometer amplifiers not available in 1976. These devices proved more stable for the high impedance operation and their configuration. Low power requirements made it practical to utilize separate faraday shields and individual power supplies for each detector preamp, thereby minimizing electrical interaction among detector channels and external interference.

Together, these modifications served to reduce the N.E.S.R. of the instrument detectors to the 10^{-8} w $cm^{-2} sr^{-1} \mu m^{-1}$ level, adequate to measure the normal background levels which had been observed at 30 km.

B. The Alaskan Measurements

The Alaskan operation in 1977 was performed in conjunction with the project Ashcan flight series, and scheduling was determined by the Ashcan operation. Assembly of the single-channel radiometer systems was completed just in time for shipment to Alaska. This restricted time frame permitted practically no testing of the radiometers beyond their calibration with an external blackbody to establish sensitivity levels.

In Alaskan tests it was found that the drive system for the internal calibration source would not operate reliably when the radiometers were cooled. Since time did not permit modifications internal to the dewar, the drive system was disabled to insure that the calibration source remain out of the field-of-view.

Final assembly and testing of a payload consisting of the four-field filter radiometer, two single-channel radiometers, the Barcus x-ray package and the Tufts University azimuth stablization system was completed on 3 June.

The three radiometers were installed in the gondola with their optical axes as nearly coincident as could be determined without optical measurements. One of the single-channel radiometers was placed such that its axis could be rotated through sequenced steps of 3^{o}, 6^{o}, 12^{o}, 30^{o} and 60^{o} by command from the ground. Data recording was done on-board via two digital tape decks and via S-band telemetry recorded at Poker Flats. Real-time monitoring was attempted at Eielson AFB, but was only partially useful due to the lack of a suitable tracking antenna.

After a delay due to problems with the command system check-out, the package was launched at 0602 ADT on 15 June 1977 and reached a float altitude of 29.3 km at 0743. The balloon stayed at float until 1302 when the flight was terminated over a suitable recovery area. The gondola was recovered the same evening in good condition.

The project Ashcan flight series started before the second of our two scheduled flights could be prepared and launched. It was necessary, therefore, to wait until completion of the Ashcan series before attempting the final flight. In the interim modifications indicated by the results of the 15 June flight were performed and some additional testing was done.

The project Ashcan series was completed on 25 June and preparations were started for an infrared flight to be launched the morning of 26 June. The liquid helium dewar of the four-field radiometer was filled on 25 June for some preliminary checks. All outputs appeared normal. Preflight cooling of the radiometer with LN_2 was started. All went well until a refill of the LHe dewar during which outputs were normal, but the boil-off rate of LHe was much greater than normal, indicating poor vacuum in the dewar. An attempt was made to repump the dewar when the LHe was exhausted, but the leak rate increased as the detector face-plate cooled, forcing cancellation of the flight.

The leak resealed as the radiometer warmed, making it apparent that the problem was associated with the external cooling of the dewar. Since a full temperature cycle on the total radiometer system required at least 24 hours, the detector module was removed from the instrument and a test fixture constructed to permit more rapid temperature cycling. The areas most susceptible to temperature-induced leaking in the dewar shell were the gold "O" ring seal between the dewar body and face-plate and the seal of the window to the face-plate. The gold "O" ring was changed and all windows seal seams were covered with a bead of epoxy. The repaired dewar maintained vacuum through one temperature cycle but failed on the next. Several "O" ring changes and additional epoxying failed to repair a dewar which would hold a vacuum through more than one temperature cycle. The time available before the cutoff data (1 July) was almost exhausted, so a new gold "O" ring was installed in the radiometer to be flown without a pre-flight temperature cycle.

Pre-flight cooling was started on 29 June for a flight scheduled the next morning. A vacuum leak developed before the radiometer was fully cooled, but the leak rate was not as great as before, so an attempt was made to cryopump the dewar with LHe. The resulting LHe hold time (30-40 minutes) was much too short for a useful flight with the four-field radiometer.

The flight of 15 June had raised some serious questions as to the validity of the data from at least one of the single-channel radiometers. The decision was made, with the concurrence of the sponsor representative, that the information gained by flying the single-channel radiometers without the four-field radiometer as a control would probably not justify the expense of the flight. The flight was, therefore, cancelled with the intention of performing a control flight at Holloman AFB at a later date.

III. SUMMARY OF RESULTS

During the 15 June flight all instrumentation functions appeared normal during the ascent to float altitude. The four-field radiometer functioned normally until approximately 1125 ADT (~3 1/2 hours at float altitude), when the coolant supply apparently ran out. The single-channel radiometers continued to generate outputs until the power was shut off prior to termination at 1302 ADT.

The validity of the outputs from the single-channel radiometers is questionable, particularly from unit #1 which began to exhibit large excursions in output level after a short period at float. These excursions differ from the fluctuation phenomena in several respects. They are predominantly repetitive, with a period of approximately two minutes, although the period changes slowly with time. They always exhibit a gradual build-up to a high level and a gradual decrease. A higher frequency (period 1 sec) is frequently superimposed on the long-period excursion. None of these characteristics are present in the four-field filter radiometer data from this flight or any fluctuation data previously obtained. These characteristics are more strongly suggestive of an electrical oscillation than an optical effect. The most likely explanation for the observed output is a gain variation in the detector preamp arising from a high frequency oscillation of the operational amplifier, possibly a result of the cooling of the preamplifier during flight. Such oscillations and high output level would cause a warming of the operational amplifier until the oscillations ceased, at which point it would cool again.

For the reasons outlined above, most of the float data from the fixed single-channel radiometer is suspect, although there is some evidence that it was functioning somewhat as a radiometer at the end of the flight.

The rotatable single-channel radiometer exhibited similar symptoms but only for short periods and with much less amplitude. Signals more characteristic of infrared activity appear on its output, but are difficult to interpret since later testing showed it badly out of focus with a resulting field-of-view limited only by the cold baffle system. In addition the time frame for comparison with the four-field radiometer is limited since the axis of the single-channel unit was rotated out of coincidence with the four-field unit at about the time the higher levels of activity began.

Weak fluctuations were observed with the four-field filter instrument starting shortly after reaching float altitude. The activity was infrequent and weak until 0830 when somewhat higher levels were observed. The activity levels were never very large and the periods of activity were short.

Three of the four detectors of the four-field instrument had excellent sensitivity, from top to bottom in the vertical plane these were #1, #2 and #4. Correlation can be tested from this data at separations of 3^{o}, 6^{o} and 9^{o}. Correlation calculations have yet to be performed on this data but inspection of the analog data shows the correlation to be less rigid than on previous flights. Previous correlation computations have been done on much stronger, longer-lasting phenomena, and appear to be different from those with a lesser degree of activity.

In summary, correlation information was obtained for fields separated at 3^{o}, 6^{o} and 9^{o} in the vertical plane, but due to the low levels of activity, it may not be representational of the stronger phases of the activity. Where feasible the data will be checked out for correlation between activity level and angular extent. Data tapes are being prepared for such purposes.

The single-channel radiometer results show the need for further testing of these units, both in the laboratory and on balloon flights. Since these radiometers are useful for other measurements, tests are being done under various other programs.

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